Encroachment of Big Sagebrush on Seeded Range in Northeastern Nevada

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Possibilities for increasing forage production on depleted range lands overgrown with big sagebrush (*Artemisia tridentata*) have been successfully demonstrated in many places. The proved formula includes brush removal and seeding adapted grasses. The introduced, dought-tolerant wheatgrasses (crested wheatgrass, *Agropyron desertorum,* formerly known commonly as the "Standard variety" and now sometimes called desert wheatgrass, and crested wheatgrass, *A. cristatum,* formerly known commonly as "Fairway strain") have been used more than native grasses for this purpose. They are generally better seed producers, easier to establish, and will tolerate as much or more grazing than native bunchgrasses found in the sagebrush zone. The native bunchgrasses have disappeared, wholly or in part, over extensive acres as a result of past heavy grazing, thereby allowing increase of brush. The question arises as to how long crested wheatgrass will persist under grazing, and to what extent it can prevent sagebrush and other undesirable species from reinvading. This paper provides information on these important points from an 825-acre planting in typical sagebrush land in Ruby Valley, Nevada.

Prior to treatment of the experimental plots in 1944, big sagebrush averaged 20 plants, 18 to 48 inches in height, plus 60 seedlings, per 100 square feet of area. Other vegetation in order of abundance included Sandberg bluegrass (*Poa secunda*), Douglas rabbitbrush (*Chrysothamnus viscidiflorus*), squirreltail (*Sitanion hystrix*), tailcup lupine (*Lupinus caudatus*), hoary phlox (*Phlox hoodii canescens*), little larkspur (*Delphinium andersoni*), Indian ricegrass (*Oryzopsis hymenoides*), arrowleaf balsamroot (*Balsamorhiza sagittata*), Great Basin wildrye (*Elymus cinereus*), and trace amounts of a few other species. Grasses occupied only 1 of every 220 square feet of area, or less than one-half of 1 percent of the ground surface.

Considering big sagebrush to be 10 percent palatable, the annual grazing capacity was judged to be 40 to 50 animal months for the 825 acres, but one experienced range man voiced his opinion that "one cow would starve on the entire area." One stockman would not risk grazing the area because of larkspur.

The area was made available for experimental seeding and demonstrations in 1944 by cooperative agreements between the Intermountain Forest and Range Experiment Station, private ranchers, Bureau of Land Management, and Humboldt National Forest. A major point of interest was to demonstrate on a large scale the feasibility of removing sagebrush and seeding rangeland to provide suitable spring forage for cattle, and thereby relieve early grazing use on certain nearby allotments of the Humboldt Forest. An average annual precipitation of approximately 12 inches and a sandy clay loam soil of average fertility, at an elevation of 5,800 feet, favored success.

Treatments and Early Responses

Four main brush-removal and seeding treatments were applied to the area: (1) 500 acres of big sagebrush were wheatland-plowed in July and August and drilled in October, 1944, at the rate of 7.8 pounds per acre; (2) 60 acres of large, brittle brush were double-railed in July and drilled similarly in October, for comparison with plowing; (3) 210 acres were plowed and broadcast-seeded simultaneously, in October and early November, at the rate of 12 pounds per acre; and (4) 55 acres, untreated in 1944, were plowed and broadcast-seeded in May, 1945.

Commercial crested wheatgrass, including both *A. desertorum* and *A. cristatum,* was seeded over most of the area. Crested wheatgrass was seeded also, with smooth brome (*Bromus inermis*) and western wheatgrass (*Agropyron smithii*), on 28 acres of poorly drained land that supported a dense stand of rubber rabbitbrush (*Chrysothamnus nauseosus*) and greasewood (*Sarcobatus vermiculatus*), with some saltgrass (*Distichlis stricta*), prior to treatment. Four other species, beardless bluebunch wheatgrass (*A. inerme*), Nevada bluegrass (*Poa nevadensis*), big bluegrass (*P. ampla*), and blue wildrye (*Elymus glaucus*), were seeded singly on small plots of one-half to one acre, and a mixture of the latter three was planted on a 4-acre plot. A year following plowing, western wheatgrass, intermediate wheatgrass (*A. intermedium*), and Russian wildrye (*E. junceus*) were drilled separately on a narrow 4-acre strip that missed being seeded.

Favorable growing conditions in the spring and summer of 1945 resulted in an excellent stand of grass seedlings. An abundance of new sagebrush seedlings occurred also, along with some old, surviving plants. Young grass and brush grew undisturbed by livestock for the first year and up to the fall of the second growing season, when light grazing by cattle was permitted. At that time, in 1947, an average yield of 1,100 pounds of air-dry crested wheatgrass forage per acre was recorded, along with an average of one old surviving sagebrush plant per 37 square feet and one sagebrush seedling per 13 square feet (Hurd, 1949).

Grazing Use

Regular spring grazing began in 1947 after the seeded area, which was about 2½ miles long by one-half mile wide, had been divided into three pastures of 245, 400, and 180 acres from north to south, respectively. It was intended to graze the north pasture heaviest, but due to water shortages in the north and sometimes middle pastures, gates were left open, and this was achieved only in 1947, when utilization there averaged 55 percent, compared to 35 percent in the middle and 30 percent in the south pastures. Such light grazing left many ungrazed plants in all pastures, some of which went ungrazed in succeeding years, developing into "wolf" plants having an accumulation of old stalks. Ungrazed plants were reduced materially in the summer of 1948, when unauthorized use following the regular grazing season increased utilization to an average of 85 percent in all pastures. Again in 1949 utilization was heavy in the south and middle pastures, averaging 86 and 82 percent, respectively, compared to a more moderate 65 percent in the north pasture. Since then estimated average utilization has varied between 50 and 85 percent, but it has been consistently heaviest in the south pasture, with the north pasture being grazed least.

Approximately 400 head of cows with calves have grazed this area for about 3 weeks each spring—the equivalent of 272 animal months annually. Cattle entered on the date they would otherwise have entered the Humboldt National Forest, usually around May 20, which provided relief on the early-season mountain range.

Crested wheatgrass was usually approaching heading by May 20, with sufficient forage to carry the large herd of cattle for the period indicated. Although other studies (Williams and Post, 1945; Barnes and Nelson, 1950; Frischknecht, *et al.*, 1953; Bleak and Plummer, 1954) have shown that highest animal gains on crested wheatgrass can be expected when grazing begins early, the cattle appeared to do well on these pastures.

Brush-Grass Status in 1954

In 1954 three transects, of 94 plots each, were run lengthwise through the area so as to cross all pastures: one near the east end, farthest from water, where use was lightest; one near the west end, closest to water, where use was heaviest; and one through the center, intermediate in use and distance from water. Plots were spaced 150 feet apart along the transects. These were supplemented with additional plots where further information was desired, so that all the major preparatory treatment areas were sampled. Brush data were obtained from 100-square-foot plots, with grass data being taken on the center one-tenth for more refined measurement. An adaptation of the square-foot density method (Stewart and Hutchings, 1937) was employed in obtaining grass basal area, and yield was obtained by the weight-estimate technique of Frischknecht and Plummer (1949).

After considerable practice in cutting sagebrush plants of different sizes and counting annual rings, it was fairly easy to divide them into age classes by inspection, as follows: (1) plants less than 3 years old, referred to as "seedlings"; (2) plants 3 to 7 years old that had invaded between 1947 and 1952; (3) plants 8 to 10 years old that would have been classified as seedlings in the 1947 survey (most plants in this class were in their tenth growing season in 1954, showing that they originated in 1945 following brush removal); and (4) old plants that survived treatment. If the age of any plant was questioned, the plant was cut and the annual rings counted.

Numbers of sagebrush plants by age classes are shown in Table 1, along with corresponding grass data. Grass data from many of the same plots are included in more than one brush class, where sagebrush plants of different age classes occurred on the same plot. Averages, however, show relations between certain characteristics of the grass and brush invasion.

The average basal area of crested wheatgrass encompassed 13.2 percent of the ground surface, but only 10.4 percent was occupied by live basal area; dead plant centers over 1½ inches in diameter made up the difference. An average of 181 crested wheatgrass plants per 100 square feet accounted for this average basal area. Grass wolf plants averaged 8.4 plants per 100 square feet, and small plants having less than a 1-inch crown diameter averaged 1.2 plants per 100 square feet.

Brush plants that invaded after the grass became established are

Table 1. Numbers of big sagebrush plants by age classes and their relation to crested wheatgrass on 282 plots in 1954.

	Age class of brush (years)			
	Less than 3	3 to 7	8 to 10	Old
Big sagebrush				
Total brush plants in class	447	24	1,228	379
Crested wheatgrass				
Number of grass wolf plants per 100 square feet	3.0	8.5	8.9	10.6
Basal-area encompassed by grass (Percent ground cover)	11.2	9.9	13.3	13.6
Live basal-area of grass (Percent ground cover)	7.8	7.6	10.4	10.8
Yield of crested wheatgrass (Pounds per acre, air-dry)	248	296	308	321

represented in the two younger age classes. These account for a little more than one-fifth of all sagebrush plants tallied. However, plants under 3 years of age were about 20 times more numerous than plants 3 to 7 years of age, showing that brush invasion has recently accelerated. Both age classes were localized on plots where the average basal area encompassed by grass was considerably less than the all-plot average of 13.2 percent. Notably, plots with brush seedlings had the highest percentage of dead basal area of grass, the lowest grass yield, and the fewer wolf plants, suggesting that recent rapid sagebrush invasion is related to heavy use of crested wheatgrass. It is significant also that these seedling plants occurred on only 15.6 percent of the plots, principally on the west transect, and more particularly in the south and middle pastures, where use had been heaviest.

Evidences of decreased use from the south to north pastures and from west to east were a decrease in the proportions of grass plants having dead centers, and an increase in the number of grass wolf plants. Thus, in the south, middle, and north pastures, plants having dead centers over 1½ inches in diameter amounted to 35, 29, and 23 percent of the total plants examined, and there were 4.2, 7.9, and 12.8 wolf plants per 100 square feet, respectively. Similarly, 41, 24, and 21 percent of the plants in the west, middle, and east transects had dead centers, and there were 4.5, 9.7, and 11.5 wolf plants per 100 square feet, respectively. It was reported in Utah that wolf plants increased greatly under 50 percent utilization, decreased slightly under 65 percent utilization, and almost disappeared under 80 percent utilization of crested wheatgrass over a 4-year period (Frischknecht, *et al.,* 1953).

The low precipitation from January 1 through May, 1954, which was barely one-half of average, accounts partly for the relatively low yields of crested wheatgrass in 1954. It is recognized, too, that grass yields tend to decline to levels somewhat lower that the high peaks reached in the first few years following seeding; general declines in yields of crested wheatgrass with age were noted by Barnes and Nelson (1950) and Bleak and Plummer (1954).

Table 2. A comparison of sagebrush plants present in both 1947 and 1954 by age class and initial ground treatment.

Preparatory ground treatment	Size of area	Old plants surviving treatment 1947	1954	Plants invading with grass establishment 1947	1954
	Acres	No. plants per 100 sq. ft.		No. plants per 100 sq. ft.	
Railed summer 1944 (Drilled Oct.)	60	4.9	2.5	8.6	4.9
Plowed summer 1944 (Drilled Oct.)	500	4.1	1.2	3.9	3.5
Plowed fall 1944 (Broadcast same time)	180	3.1	1.1	6.9	4.5
Plowed late fall 1944 (Broadcast same time)	30	4.4	2.1	12.3	8.4
Plowed spring 1945 (Broadcast same time)	55	3.1	1.7	3.5	4.2

Only 24 of the total 2,078 brush plants were tallied in the 3- to 7-year age class, and they occurred on 4.6 percent of the plots. It would be difficult, if not impossible, to ascertain grass conditions during the period when these brush plants became established, but it is doubtful whether effects of heavy grazing had yet become pronounced. Apparently, crested wheatgrass largely excluded sagebrush established during this period, except where openings between grass plants were larger than usual. Observations elsewhere in the Intermountain region indicate that sagebrush seedlings can usually be found in the spring, wherever a seed source is present, but their chances for survival are much less in a full, vigorous stand of grass than where the stand is thin at the outset (Blaisdell, 1949), or weakened by too heavy use (Frischknecht and Plummer, 1955).

Approximately three-fifths of the sagebrush plants tallied on the plots were in the 8- to 10-year class, having become established simultaneously with grass. They were found on 87 percent of the plots, well distributed over the area. Plowing had prepared a good seedbed for young brush as well as young grass, and the two developed together. As would be expected for this large representation of plots, numbers of wolf plants, basal area, and yield of crested wheatgrass approximated averages for the area as a whole .

Old, surviving sagebrush accounted for nearly another fifth of the total sagebrush plants in 1954. These, too, were well distributed over the area, occurring on 61 percent of the plots. These old survivors are probably the parents of many brush plants in the other classes. There were a few more crested wheatgrass wolf plants than average on these plots, and grass basal area and yield were a little higher than averages for the area as a whole.

Sagebrush plants in the latter two age classes were the only plants present in both 1947 and 1954. Table 2, relating numbers of sagebrush in both years to preparatory treatment, shows that reductions occurred in plant numbers of both age classes over the 7-year period. The one exception was the spring-plowed area, where more 8- to 10-year-old brush plants occurred in 1954 than had been seedlings in 1947, an increase that could be due to sampling error. The

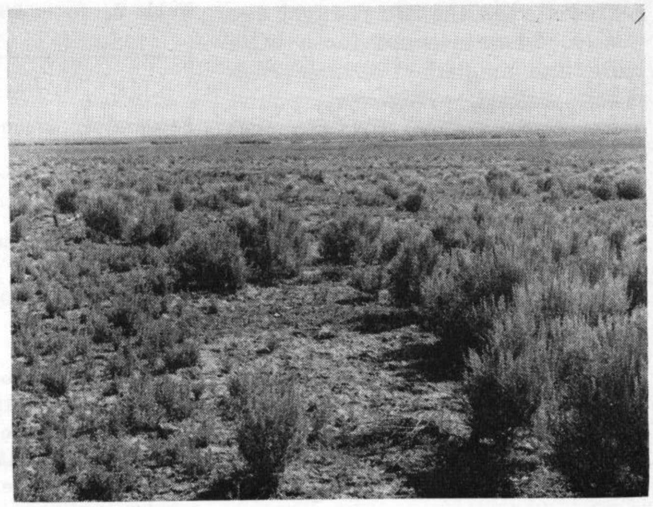

FIGURE 1. *Left*: An excellent stand of blue wildrye and big bluegrass with a small amount of Nevada bluegrass was present on this area in 1947. *Right*: By 1954 the seeded grasses had almost disappeared and big sagebrush was again taking over. The large sagebrush plants were seedlings in 1947; the smaller plants have invaded since 1947.

main point is that plant numbers did not decrease here as on the other areas. That there were only 70 percent as many crested wheatgrass plants per acre on this area as on the others may have been a contributing factor. It appeared that sagebrush plants of the 8- to 10-year class tended to stabilize at a constant number, between 4 and 5 plants per 100 square feet.

Aside from this exception, areas having the most brush plants in 1947 had the most brush plants in 1954. It is noteworthy that more brush plants were found on the railed area than on the comparable plowed area as late as 10 years after treatment. This was true both for plants that survived treatment and those that invaded shortly after treatment. It is noteworthy, also, that the area plowed in the fall, and especially the area plowed in late fall, contained more brush plants that invaded shortly after treatment than the area plowed the previous summer or the area plowed the following spring. These findings are in agreement with those of Bleak and Miller (1955) who found that late fall plowing resulted in more sagebrush seedlings the following spring than plowing done earlier before brush seed approached maturity. Another possible seed source for some of the many brush plants on the late-fall treated area was the adjacent, 55-acre tract that was not treated until the spring of 1945.

Performances of Other Seeded Grasses

Performances of the other seeded grasses demonstrate the outstanding superiority of crested wheatgrass on the area. The mixture of blue wildrye, big bluegrass, and Nevada bluegrass produced an excellent stand at the outset (Fig. 1. *Left*). However, numbers of plants as well as yields of these species have been decreasing since 1947, both under grazing and where protected. Few plants of these species remained in 1954, and sagebrush is reoccupying the area (Fig. 1. *Right*).

Bluebunch wheatgrass, drilled on a ½-acre plot, has received heavier use than nearby crested wheatgrass. This is in contrast to some observations elsewhere in the Intermountain region. It probably results from the late spring grazing, since palatability of crested wheatgrass declines greatly as it approaches maturity. Even where bluebunch wheatgrass had maintained a good stand, plant vigor was poor and forage production less than that of crested wheatgrass in 1954. Big sagebrush has encroached more on both grazed and protected plots of bluebunch wheatgrass than on adjoining plots of crested wheatgrass.

Drillings of intermediate wheatgrass, western wheatgrass, and Russian wildrye into a dense stand of annuals in the fall of 1945 produced poor stands. The adverse initial factors from planting a year after plowing make this an unfair test, but even if good initial stands had been obtained, it is doubtful whether these species would have surpassed crested wheatgrass on this site over the 10-year period.

Rubber rabbitbrush, greasewood, and saltgrass again dominate the areas of heavier soil which had been planted to a mixture of crested wheatgrass, western wheatgrass, and smooth brome. The latter two species have almost disappeared and crested wheatgrass plants are small, occurring mainly where protected by rabbitbrush. Experience elsewhere indicates that Russian wildrye and possibly tall wheatgrass (*A. elongatum*) would have been better suited to this particular area of heavy soil having a high water table part of the year.

Other Native Species in 1954

Douglas rabbitbrush, the second most abundant brush species, averaged 4.5 plants per 100 square feet over the area in 1954. The comparative number prior to treatment is unknown, but it is doubtful whether this species has decreased in abundance because of treatment, and possibly it has increased, judging from the numbers of relatively small plants.

Sandberg bluegrass was the most abundant native herbaceous species in 1954, as it was prior to treatment. Much of this grass was undoubtedly killed by plowing, but new plants came from seed on the ground in the favorable spring of 1945 or have increased since.

All other species previously listed as being present prior to treatment were present in 1954, most of them being somewhat less common. Larkspur appeared to be markedly less abundant in 1954. In contrast, hoary phlox appeared to have increased considerably since the area was plowed and seeded. This species was found generally over the area in 1954; either it was not killed by plowing or it has reinvaded.

The introduced poisonous weed, *Halogeton glomeratus,* was first observed inside the area in 1951 and was thick on disturbed and barren spots in the west ends of the south and middle pastures by 1954 (Fig. 2). It was confined to ridgetops, along roads, near gates, salt grounds, and on rodent diggings where crested wheatgrass stands were thin and most heavily grazed. Halogeton was not found where crested wheatgrass was thrifty and formed a full stand.

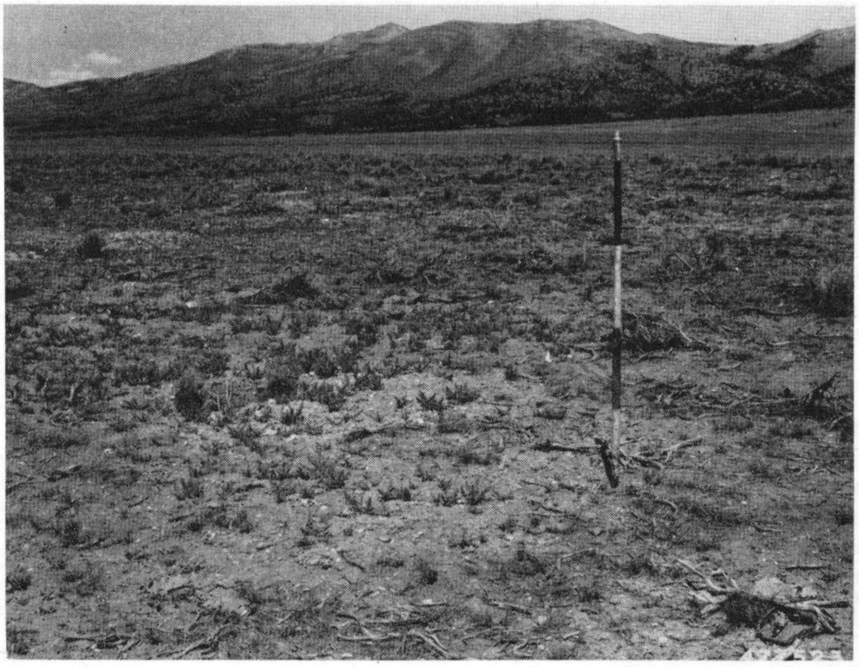

FIGURE 2. Halogeton is growing vigorously on the disturbed area to left of staff but is not found in crested wheatgrass to right of staff.

Summary

Survey of an 825-acre grazed crested wheatgrass planting in Ruby Valley, Nevada, 10 years after treatment showed that slightly more than one-fifth of the present total big sagebrush plants invaded after the grass became established. Of these, plants less than 3 years of age were about 20 times as numerous as plants 3 to 7 years of age, indicating that brush invasion has accelerated. These youngest plants were localized on 15.6 percent of the plots where grazing use had been consistently heavy.

The very few brush plants in the 3- to 7-year age class were confined to 4.6 percent of the plots with thinner than average stands of crested wheatgrass; apparently elsewhere, grass tended to exclude sagebrush between the third and seventh years following seeding.

Sagebrush plants that had become established with the seeded grass (8 to 10 years old in 1954) were the most numerous and widespread of any class. These accounted for three-fifths of the total plants and occurred on 85 percent of the plots.

Old sagebrush plants that survived treatment accounted for a little less than one-fifth of the total plants and occurred on 61 percent of the plots. These plants were probably the seed source for many sagebrush plants in the other age classes.

Plants in the latter two age classes decreased considerably in numbers from 1947 to 1954, except for 8- to 10-year-old plants on a 55-acre tract treated in the spring of 1945. The failure of young sagebrush to decrease under this treatment as under the others may reflect the establishment of fewer than average crested wheatgrass plants on this area. A fall-treated area, and especially a tract treated in late fall, contained more sagebrush plants that invaded shortly after treatment than areas similarly treated earlier, before brush seed maturity. A railed area contained more sagebrush plants than a comparable wheatland-plowed area, both in numbers of old survivors and plants that invaded soon after treatment.

Blue wildrye, big bluegrass, Nevada bluegrass, and bluebunch wheatgrass were inferior to crested wheatgrass on this site. Tests with intermediate wheatgrass, Russian wildrye, and western wheatgrass were inconclusive, but it is doubtful whether any would have surpassed crested wheatgrass. Rubber rabbitbrush, greasewood, and saltgrass have again dominated a 28-acre area having heavy, alkali soil which was planted to a mixture of crested wheatgrass, western wheatgrass, and smooth brome.

Most native species, present prior to treatment, were present also in

1954, though generally less common. Larkspur appeared to have been greatly reduced, whereas hoary phlox and Douglas rabbitbrush appeared to have increased.

Halogeton increased rapidly during the 4 years it has been on the area, but only in heavily grazed and barren spots; it was not found in full, vigorous stands of crested wheatgrass.

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